

REMARKS

The Final rejection mailed July 23, 2003, in connection with the above-identified application is noted. As a complete response thereto, a Notice of Appeal was filed January 23, 2004, together with a necessary Petition for Extension of Time.

Moreover, for withdrawing finality of the Office Action mailed July 23, 2003, and for continuing prosecution in connection with the above-identified application, the concurrently filed Request for Continued Examination (RCE) Transmittal is noted. This RCE Transmittal indicates that as the necessary Submission therefor, amendments to the claims are being submitted; moreover, an Information Disclosure Statement is also being submitted. Thus, it is respectfully submitted that a proper Request for Continued Examination is being filed, such that finality of the Office Action mailed July 23, 2003 must be withdrawn.

By the present amendments, Applicants are amending claim 19 to recite that the copper is in a Cu phase having a hardness in a range of 75-80 Hv, and that the cuprous oxide is in a Cu₂O phase having a hardness in a range of 210-230 Hv.

Claim 24 has been similarly amended. Note, for example, the second full paragraph on page 22 of Applicants' specification. Moreover, claim 23 has been amended to recite that the copper phase and the cuprous oxide phase are oriented in a direction of orientation, thereby providing antecedent basis for recitations in connection with the direction of orientation set forth further in claim 23. As for this direction of orientation, note, for example, Example 4 on pages 24-26 of Applicants' specification, in particular the last paragraph on page 25 of Applicants' specification.

In addition, Applicants are amending claim 25 to recite that the sintered composite material "has been" subjected to plastic working.

Moreover, Applicants are adding new claims 26-28 to the application.

Claim 26, dependent on claim 25, recites that the inorganic particles have an average coefficient of thermal expansion equal to or smaller than $5.0 \times 10^{-6}/^{\circ}\text{C}$, in the range of 20-150°C, and a Vickers hardness of 300 or less; and claim 27, dependent on claim 26, recites that the average coefficient of thermal expansion is equal to or smaller than $3.5 \times 10^{-6}/^{\circ}\text{C}$. Claim 28, dependent on claim 25, recites that the composite material includes, additionally, ceramic particles having a specified Vickers hardness and average particle diameter, and also specifies amount of these ceramic particles in the composite material.

In connection with the newly added claims, note, for example, the paragraph bridging pages 11 and 12 of Applicants' specification.

Applicants respectfully traverse the rejection of claim 23 under the second paragraph of 35 USC §112, as set forth in Item 4 on page 2 of the Office Action mailed July 23, 2003, especially insofar as this rejection is applicable to the presently amended claim 23. Thus, note that presently amended claim 23 recites that the copper and cuprous oxide phases are oriented in a direction of orientation; it is respectfully submitted that such a direction of orientation would have been clear to one of ordinary skill in the art, and, specifically, it is clear in light of the description in connection therewith, for example, in Example 4 on pages 24 and 25 of Applicants' specification. Thus, contrary to the conclusion by the Examiner in Item 4 on page 2 of the Office Action mailed July 23, 2003, it is respectfully submitted that claim 23 is clear as to what is meant by the direction of orientation; and, in particular, it is respectfully submitted that claim 23 is sufficiently clear, for satisfying requirements of the second paragraph of 35 USC §112, as to a composite material having a thermal

conductivity in a direction of orientation that is greater than twice the thermal conductivity in a direction perpendicular to the direction of orientation.

Applicants respectfully submit that all of the claims presented for consideration by the Examiner patentably distinguish over the teachings of the references applied by the Examiner in rejecting claims in the Office Action mailed July 23, 2003, that is, the teachings of the U.S. Patents to Scorey, No. 5,292,478, to Lanzi, et al., No. 4,270,266, and to Ishikawa, et al., No. 6,110,577, under the provisions of 35 USC §103.

It is respectfully submitted that the teachings of the applied prior art would have neither disclosed nor would have suggested such a composite material as in the present claims, comprised of copper and cuprous oxide, with the copper being in a Cu phase having a hardness in a range of 75-80 Hv and the cuprous oxide being in a Cu₂O phase having a hardness in a range of 210-230 Hv, the composite material being sintered. See claim 19; note also claim 24.

In addition, it is respectfully submitted that the teachings of the applied prior art would have neither disclosed nor would have suggested such a composite material including metal and inorganic particles, as in the present claims, wherein the metal includes at least one of Au, Ag, Cu and Al and the inorganic particles include at least one of copper oxide, tin oxide, lead oxide and nickel oxide, the composite material being sintered and the sintered composite material having been subjected to plastic working. See claim 25.

Furthermore, it is respectfully submitted that the teachings of the applied references would have neither disclosed nor would have suggested such a composite material as in the present claims, having features as discussed

previously, and wherein this material is further defined as having a coefficient of thermal expansion of 5.0×10^{-6} to $14 \times 10^{-6}/^{\circ}\text{C}$ (see claim 20); and/or wherein the composite material has a thermal conductivity of 30-225 W/m·K in a range of room temperature to 300°C (see claim 21; note also claim 22); and/or wherein the thermal conductivity of the composite material in the direction of orientation of the copper and cuprous oxide phases is greater than twice the thermal conductivity in a direction perpendicular to the direction of orientation (see claim 23); and/or wherein the inorganic particles have an average coefficient of thermal expansion equal to or smaller than $5.0 \times 10^{-6}/^{\circ}\text{C}$, in the range of 20-150°C, with a Vickers hardness of 300 or less (see claim 26), more specifically wherein the average coefficient of thermal expansion is equal to or smaller than $3.5 \times 10^{-6}/^{\circ}\text{C}$ (see claim 27); and/or wherein the material further includes ceramic particles having a Vickers hardness of at least 1000 and an average particle diameter of at most 3 μm, in an amount of at most 5vol% (see claim 28).

The invention as claimed in the above-identified application is directed to a composite material having a low thermal expansivity and a high thermal conductivity, useful, for example, for heat radiators for power semiconductor devices as well as other semiconductor devices.

As semiconductor devices involve heat during operation and are subject to malfunction if heat is accumulated, a heat radiator with good thermal conductivity for heat dissipation is needed. Moreover, the radiator, which is bonded to, e.g., a semiconductor element either directly or indirectly through an insulating layer, must have a low thermal expansivity for good matching with the semiconductor element. Moreover, it is desired that the material used for the heat radiator be good in plastic

workability, so that it can easily be formed into necessary shapes (e.g., a thin plate, without the need for multiple and complex manufacturing steps).

Against this background, Applicants provide a composite material having a small coefficient of thermal expansion, yet which has a high thermal conductivity such that it can efficiently conduct heat away from a semiconductor element, and which has good workability so as to easily be formed into a heat radiator.

Applicants have found that by utilizing a composite material having a metal that includes at least one of Au, Ag, Cu and Al, preferably Cu, and including cuprous oxide, i.e., Cu₂O, or generally, inorganic particles including at least one of copper oxide, tin oxide, lead oxide and nickel oxide, the inorganic particles being dispersed in the composite material, with the composite material having been sintered, a composite material is achieved having good thermal conductivity and a low coefficient of thermal expansion, yet which can easily be plastic worked to form the desired shape for the heat radiator.

In particular, the inorganic particles of the recited oxides are comparatively soft and stable after sintering, providing good plastic workability (either hot or cold) after sintering. Note the paragraph bridging pages 11 and 12 of Applicants' specification.

In addition, through use of a composite material including cuprous oxide (Cu₂O) and copper, with Cu₂O in an amount of 20% or more, the composite material has a high coefficient of thermal conductivity required of the radiator plate; and with Cu₂O in an amount of 80% or less, the composite material has sufficient thermal conductivity and structural strength. See the first full paragraph on page 14 of Applicants' specification.

Moreover, the copper composite material according to the present invention, composed of Cu and Cu₂O, which have a low hardness, is capable of cold or hot working, such as rolling and forging, carried out after sintering. This working leads to anisotropic thermal conductivity, which contributes to strength or some applications which need heat conduction in a specific direction. Note the paragraph bridging pages 15 and 16 of Applicants' specification.

Scorey discloses a composite material having utility in electrical and electronic applications, the material comprising a composite matrix of a first metal material and a plurality of discrete elements of a low expansion phase material secured by the matrix material. In an embodiment, this patent discloses that the continuous matrix material is copper and the low expansion phase material is molybdenum. See column 2, lines 25-37. In forming this composite material, this patent discloses that an oxide of the matrix component, for example, cuprous oxide, is blended with the expansion phase material, e.g., molybdenum; and the blended powders are then heated so as to form a coating of the matrix material on the low expansion phase material. See column 2, lines 43-55. Note also column 3, lines 5-8 and 16-24; and column 4, lines 55-61. See also Example I bridging columns 4 and 5 of this patent.

It is respectfully submitted that Scorey discloses copper-molybdenum (not copper-cuprous oxide) composite material; the cuprous oxide has been reduced for forming the copper of the copper-molybdenum composite. It is respectfully submitted that this patent would have neither disclosed nor would have suggested, and in fact would have taught away from, the composite material of copper and cuprous oxide, and advantages thereof as in the present invention, much less the phases of these materials and hardness of these phases, as in the present claims.

In this regard, hardness of molybdenum as in Scorey is 124 Hv, less than hardness of the cuprous oxide in the present invention.

While Scorey discloses use of cuprous oxide in forming the composite therein, the cuprous oxide is reduced in forming the composite and does not form a part of the final composite. It is respectfully submitted that Scorey would have neither taught nor would have suggested the present invention, including the copper and cuprous oxide (or metal which is at least one of Au, Ag, Cu and Al, and inorganic particles including at least one of copper oxide, tin oxide, lead oxide and nickel oxide), and advantages of this composite material as discussed in the foregoing.

The contention by the Examiner in Item 6 on pages 3 and 4 of the Office Action mailed July 23, 2003, that Scorey discloses a composite comprised of copper and cuprous oxide, the Examiner referring to the Abstract, column 4, line 68 and column 6, lines 61-63 of Scorey, is respectfully traversed. Again, it is emphasized that Scorey discloses cuprous oxide being used for forming the copper; and in Example I bridging columns 4 and 5, as well as in Example V in column 6, refers to cuprous oxide being used and thereafter reduced to form a copper powder, with Example V providing additional copper powder to provide increased amounts of copper. It is respectfully submitted that this patent would have neither disclosed nor would have suggested, and in fact would have taught away from, the composite material of the present invention, having both copper and cuprous oxide; or having metal and inorganic particles of the specific materials as in claim 25.

The contentions by the Examiner in connection with product-by-process recitations is noted. Of course, where the processing provides a different product, and, in particular, provides a product having advantageous characteristics, such

processing must be considered in determining patentability of the structure. See In re Luck, 177 USPQ 523, 525 (CCPA 1973). In view of advantages achieved by the present invention, and noting that the sintering provides a recognizable structure different from, e.g., a totally melted and then solidified structure, it is respectfully submitted that the presently claimed structure patentably distinguishes over the teachings of the applied prior art.

It is respectfully submitted that the secondary references as applied by the Examiner would not have rectified the deficiencies of Scorey, such that the presently claimed invention as a whole would have been obvious to one of ordinary skill in the art.

Ishikawa, et al. discloses a composite material used for heat sinks for semiconductor devices, the composite material including a porous sintered compact impregnated with copper or a copper alloy, the porous sintered compact being obtained by pre-calculating a porous body having a coefficient of thermal expansion which is lower than a coefficient of thermal expansion of copper so that a network structure is formed. See column 3, lines 12-24. This patent discloses that it is desirable that the porous sintered compact comprises at least one or more compounds selected from a group consisting of SiC, AlN, Si₃N₄, B₄C and BeO, and that the ratio (impregnation rate) of the copper or the copper alloy is 20% by volume to 70% by volume. See column 3, lines 41-45. Note also column 11, lines 9-12, 25-30, 41 and 42. This patent further discloses that it is desirable to improve the impregnation rate by adding, for example, Be, Al, Si, Mg, Ti, and Ni, in a range up to 1%. Note column 12, lines 4-8.

It is emphasized that according to Ishikawa, et al., the copper is melted and impregnated into the, e.g., SiC. Such disclosure, even if properly combinable with the teachings of Scorey, would have neither disclosed nor would have suggested, and in fact would have taught away from, the sintered structure according to the present invention. It is emphasized that the impregnated structure of Ishikawa, et al. is a specific structure, not merely processing, which would be different from the sintered structure according to the present invention, and would have neither disclosed nor would have suggested such sintered structure.

In addition, it is emphasized that Ishikawa, et al. utilizes porous SiC, with copper being impregnated therein. It is respectfully submitted that the teachings of Ishikawa, et al., even in combination with the teachings of Scorey, would have neither disclosed nor would have suggested the copper and cuprous oxide, as in the present invention and advantages thereof as discussed previously.

Lanzi discloses a method of making improved ignition distributor motor electrodes for internal combustion engines. This patent discloses that a mixture, comprising by weight, at least half copper oxide and a minor portion of silica or silica and alumina, is fused; and, upon cooling, a friable glassy material with separate, substantially non-crystalline, cuprous oxide and silica-alumina microphases forms. Particles of this multiphase material are then subjected to a chemically reducing atmosphere at an elevated temperature for a time sufficient to selectively reduce the cuprous oxide phase to copper metal, and the reduced metal-silica composite particles are then comminuted to a fine powder and mixed with copper powder or other conductive metal powders of mesh similar to that of the composite particles. The powder mixture is then pressed substantially into the shape of a desired rotor

electrode and sintered to form a densified, wear resistant, rotor segment by well known powder metallurgy techniques. Note column 2, lines 5-35. This patent further discloses that the method provides a rotor electrode which lowers breakdown voltages at the gap and suppresses radio frequency noise. See column 3, lines 62-65.

Initially, it is emphasized that Lanzi, et al. is concerned with forming an ignition distributor rotary electrode for internal combustion engines, in order to lower breakdown voltages at the gap and suppress radio frequency noise. Scorey, in comparison, is concerned with providing heat dissipating elements having improved thermal conductivity properties. In view of the large difference in technologies involved in Lanzi, et al. on the one hand, and in Scorey, on the other, and in view of different problems addressed by each, it is respectfully submitted that one of ordinary skill in the art concerned with in Scorey would not have looked to the teachings of Lanzi, et al. In other words, it is respectfully submitted that Scorey and Lanzi, et al. are directed to non-analogous arts.

Moreover, noting especially the differences in involved technologies and problems addressed, it is respectfully submitted that there would have been no motivation for combining the teachings of Lanzi, et al. with the teachings of Scorey, as applied by the Examiner.

In any event, even assuming, arguendo, that the teachings of Scorey and of Lanzi, et al. were properly combinable, such combined teachings would have neither disclosed nor would have suggested the presently claimed invention, of the composite material including, inter alia, cuprous oxide together with copper, and advantages thereof. It is emphasized that in Lanzi, et al., as with Scorey, the

cuprous oxide phase is reduced to copper metal. Thus, the final ignition distributor rotary electrode in Lanzi, et al. would not include cuprous oxide, but rather would include copper metal with the silica-alumina microphases. It is respectfully submitted that the combined teachings of Scorey and of Lanzi, et al., even if properly combinable, having had the cuprous oxide reduced, would have taught away from the presently claimed composite material including cuprous oxide together with copper.

The contention by the Examiner in the Office Action mailed July 23, 2003, that Applicants have not established the critical nature for amounts of cuprous oxide or for the coefficient of thermal expansion, is respectfully traversed. It is respectfully submitted that Applicants' original disclosure shows unexpectedly better results achieved according to the present invention, having the various ranges as in the present claims. Similarly, in connection with the thermal conductivity, from Applicants' disclosure as a whole it is clear that a relatively high coefficient of thermal conductivity is a desired result; and it is respectfully submitted that Applicants have shown desirable features according to their invention, with respect to the various ranges.

In view of the foregoing comments and amendments, reconsideration and allowance of all claims remaining in the application are respectfully requested.

To the extent necessary, Applicants petition for an extension of time under 37 CFR 1.136. Please charge any shortage in fees due in connection with the filing of this paper, including extension of time fees, to the Deposit Account No. 01-2135 (Case No. 501.38171X00), and please credit any excess fees to such Deposit Account.

Respectfully submitted,

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